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Lookback: Sandia ParaChoice Model

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Overview

Purpose of the model?

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How does the model work?

-
-

How has the model evolved?

-
-

What have we learned looking back?

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-
-

How has looking back pointed us forward?

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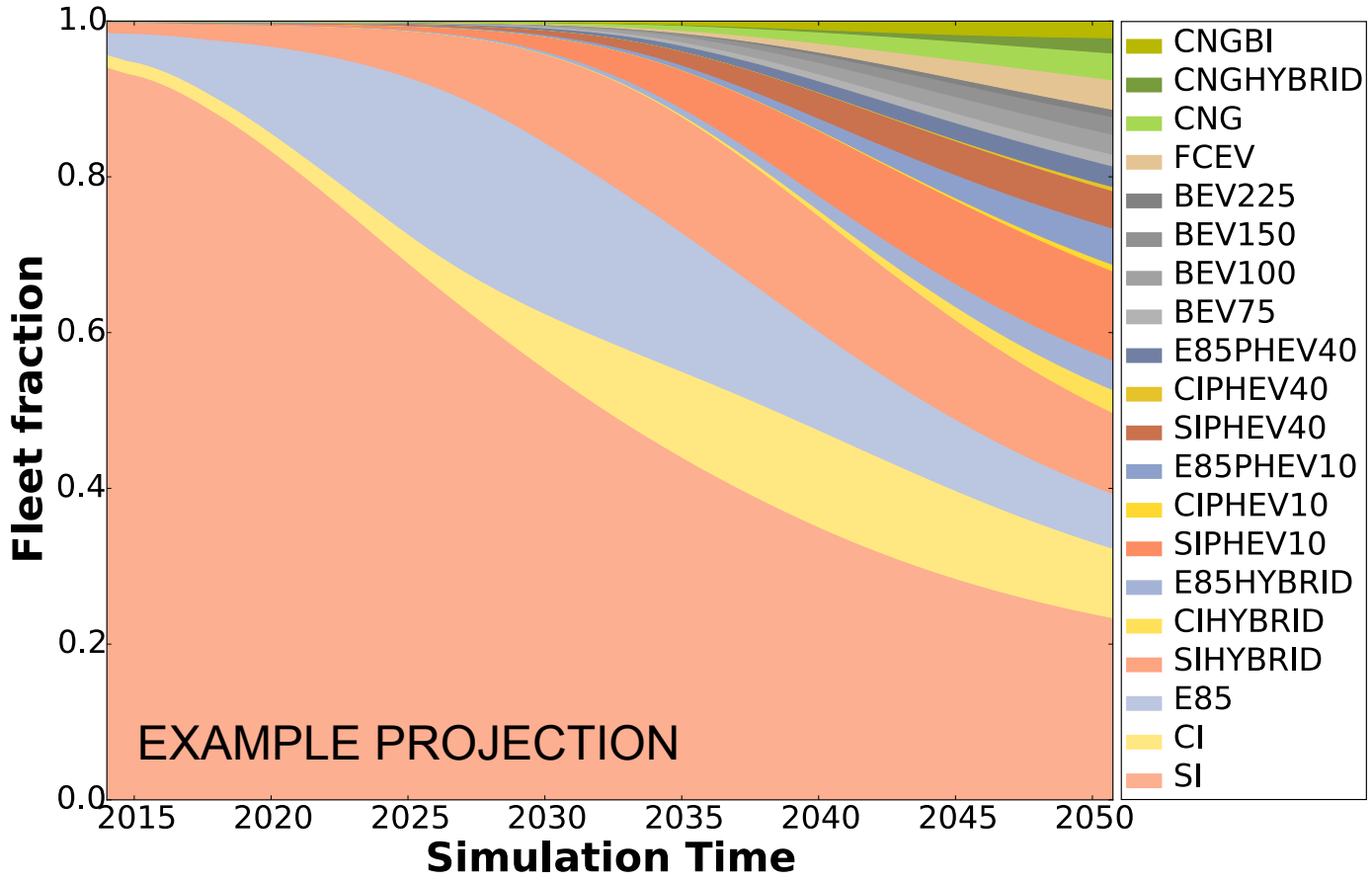
-

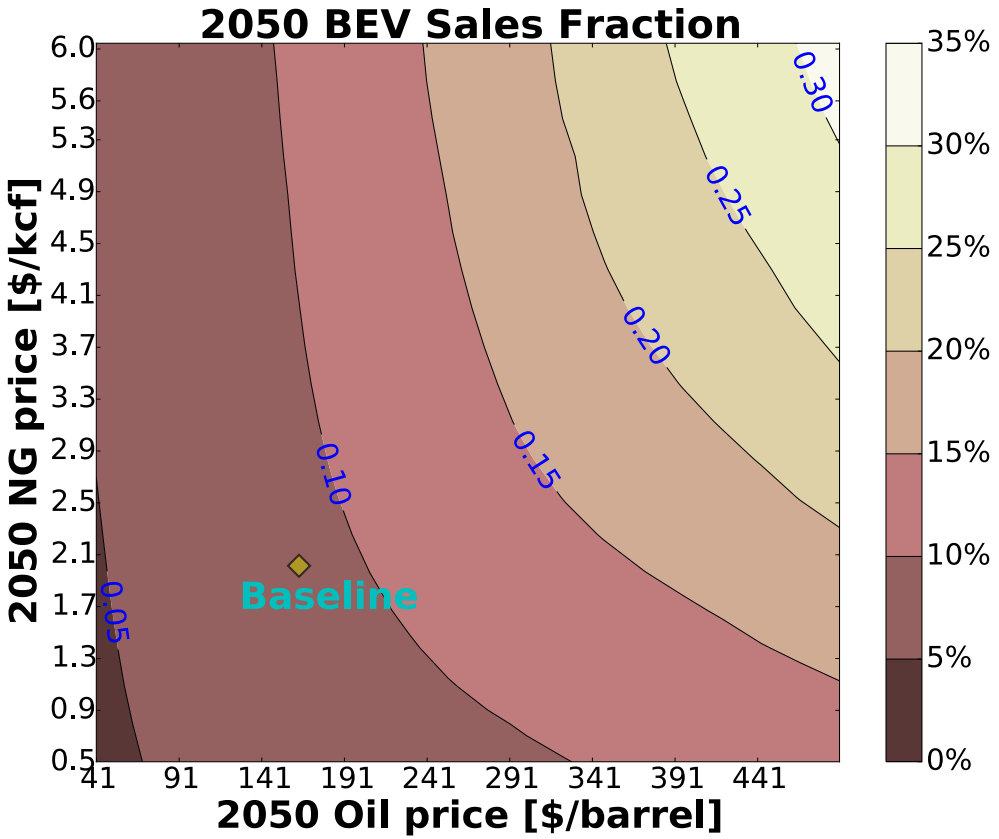
Purpose of the model?

- Understand composition of US LDV stock through 2050
  - AEVs compete for market share given technology and fuel costs and vehicle inconveniences
  - Tracks GHG emissions and fuel use



Purpose of the model?

- Understand composition of US LDV stock through 2050
  - AEVs compete for market share given technology and fuel costs and vehicle inconveniences
  - Understand GHG emissions and fuel use
- Sensitivities to commodity prices, technology advancements, policy …



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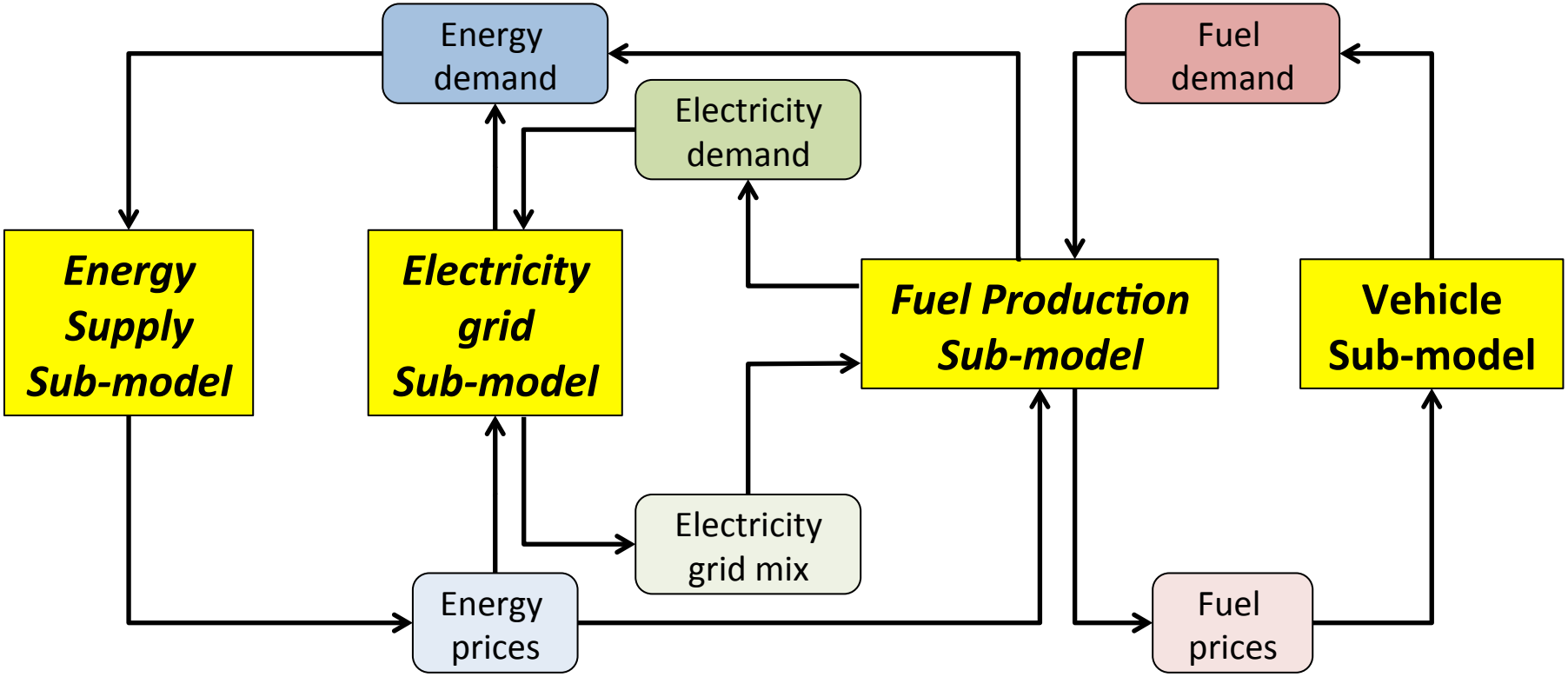
How does the model work?



Vehicle Sub-model

Consumer/Vehicle Stock

Powertrain

SI
SI Hybrid
SI PHEV10
SI PHEV40
CI
CI Hybrid
CI PHEV10
CI PHEV40
CNG
CNG Hybrid
CNG Bi-fuel
E85 FFV
E85 FFV Hybrid
E85 FFV PHEV10
E85 FFV PHEV40
BEV75
BEV100
BEV150
BEV225
FCEV

State

48 CONUS + Washington, DC

Density

Urban
Suburban
Rural

Size

Compact
Midsize
Small SUV
Large SUV
Pickup

Age

0-46 years

Housing type

- Single family home without NG
- Single family home with NG
- No access to home charging/ fueling

Driver Intensity

High
Medium
Low

Generalized Vehicle Cost

Recurring Costs

- Fuel
- Annual incentives
- Range penalty:
  $ value of time X time spent refueling

Amortized Upfront Costs

- Purchase Price
- One time incentives
- Infrastructure penalty:
  $ value $\exp[-a\, n_j/n_{gas}]$
- Value of model diversity:
  $\ln(m_j/m_{SI})$

Nested Logit Choice Function for Powertrain Selection

SALES

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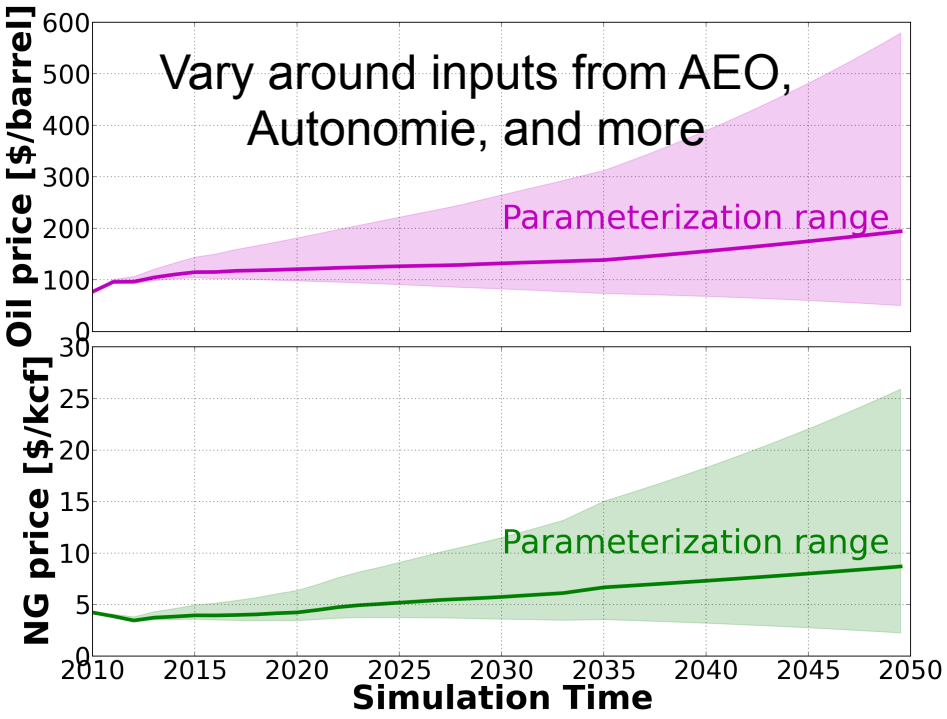
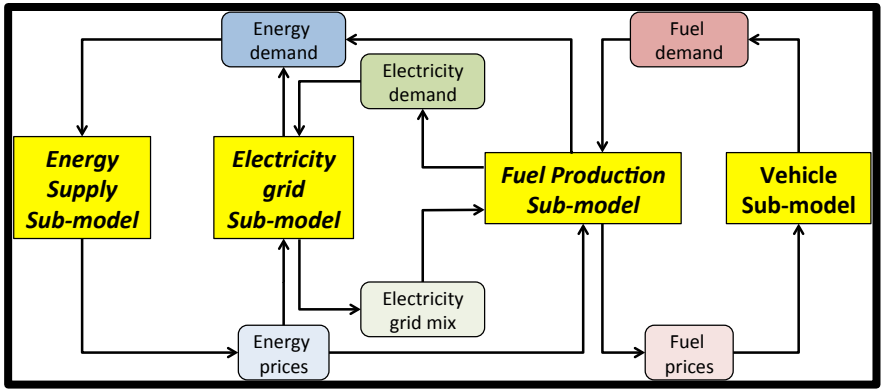
How does the model work?

- Feedback between energy and vehicle stock





X 1000

No one projection is guaranteed to be correct- but we can probe sensitivities, trade space

Purpose of the model?

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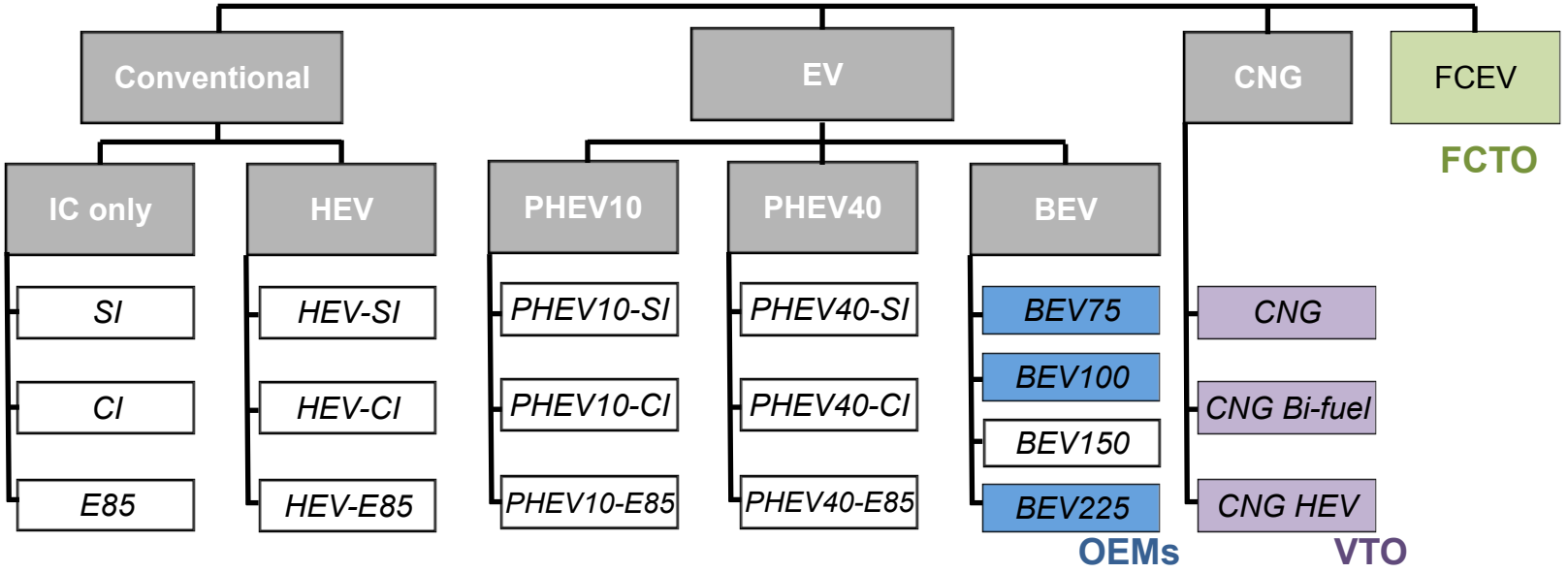
How does the model work?

- Feedback between energy and vehicle stock
- Run thousands of times to create scenario library and probe sensitivities

How has the model evolved?

How has the model evolved?

- 2010: internally funded program to understand energy / LDV stock dynamics
- Added vehicle technologies



Parametric analysis of technology and policy tradeoffs for conventional and electric light-duty vehicles. *Energy Policy* 2012

A parametric study of light-duty natural gas vehicle competitiveness in the United States through 2050. *Applied Energy* 2014

A parametric analysis of future ethanol use in the light-duty transportation sector: Can the US meet its Renewable Fuel Standard goals without an enforcement mechanism?. *Energy Policy* 2014

The implications of modeling range and infrastructure barriers to battery electric vehicle adoption. *Transportation Research Letters* 2015

History v. Simulation: An analysis of the drivers of alternative energy vehicle sales, *Manuscript submitted for publication* 2015

- Continual updates for evolving input data:
  - Autonomie projections, AEO projections, vehicle registration data, GREET emissions, state laws and incentives, refueling station densities
- Added 'validation' capability – allows lookback analysis

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- Capability, technology additions – response to OEMs, to support new projects
- Data updates – to support new work and keep model current

What have we learned looking back?

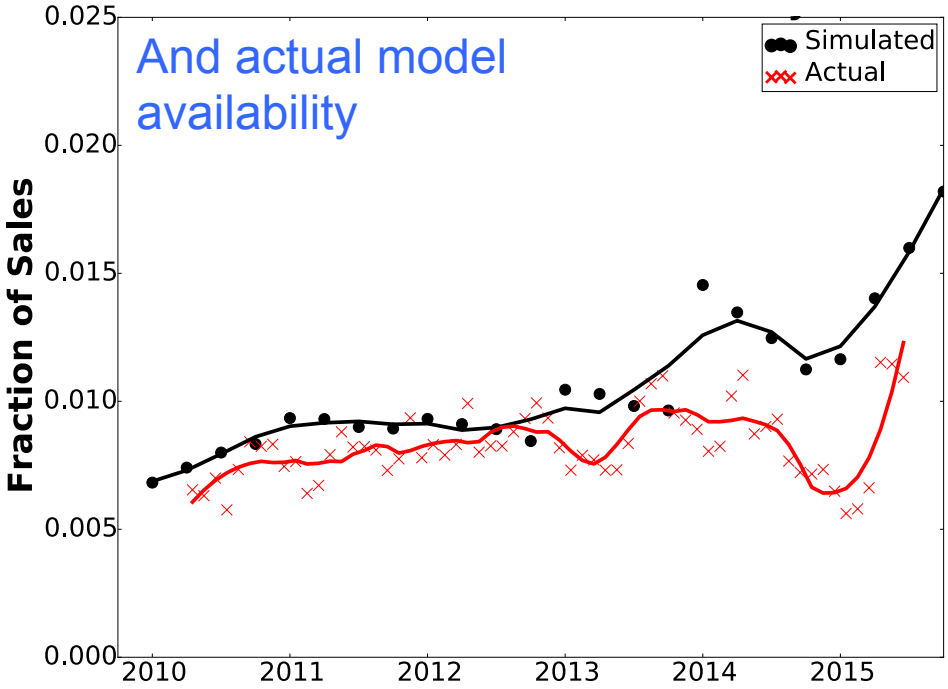
Study: Compare simulated and actual sales fractions of AEVs from 2010

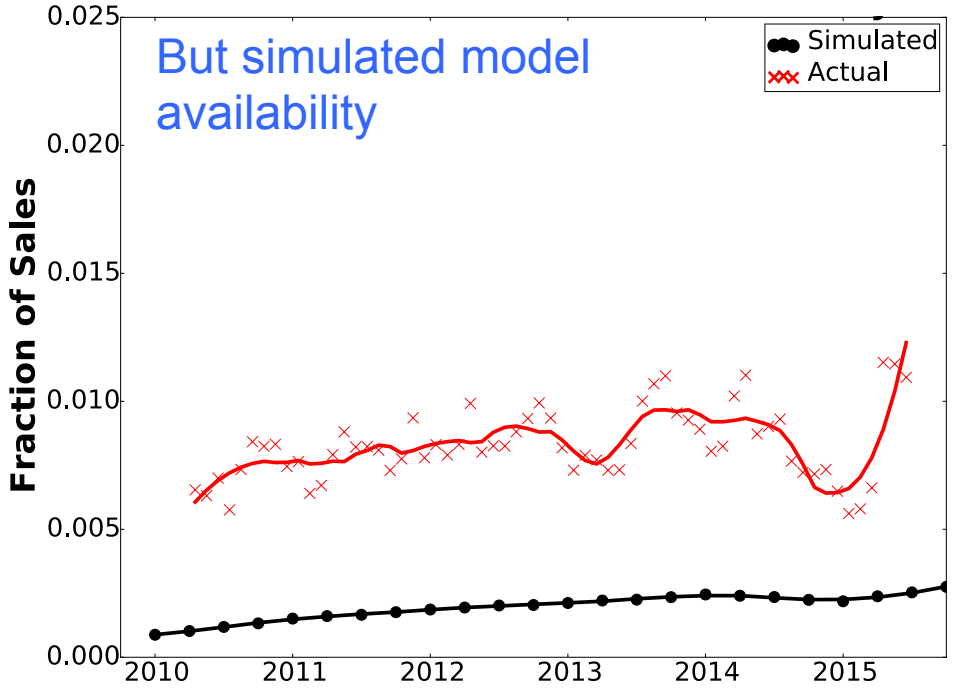
Remove uncertainty by looking back (rather than parameterizing):

- Energy and fuel prices
- State of technology
- Policy
- Consumer demographics

Diesel vehicles- simulation capturing trends and scales, vehicle model availability is very important

Simulations using historical data for energy prices, technology costs,

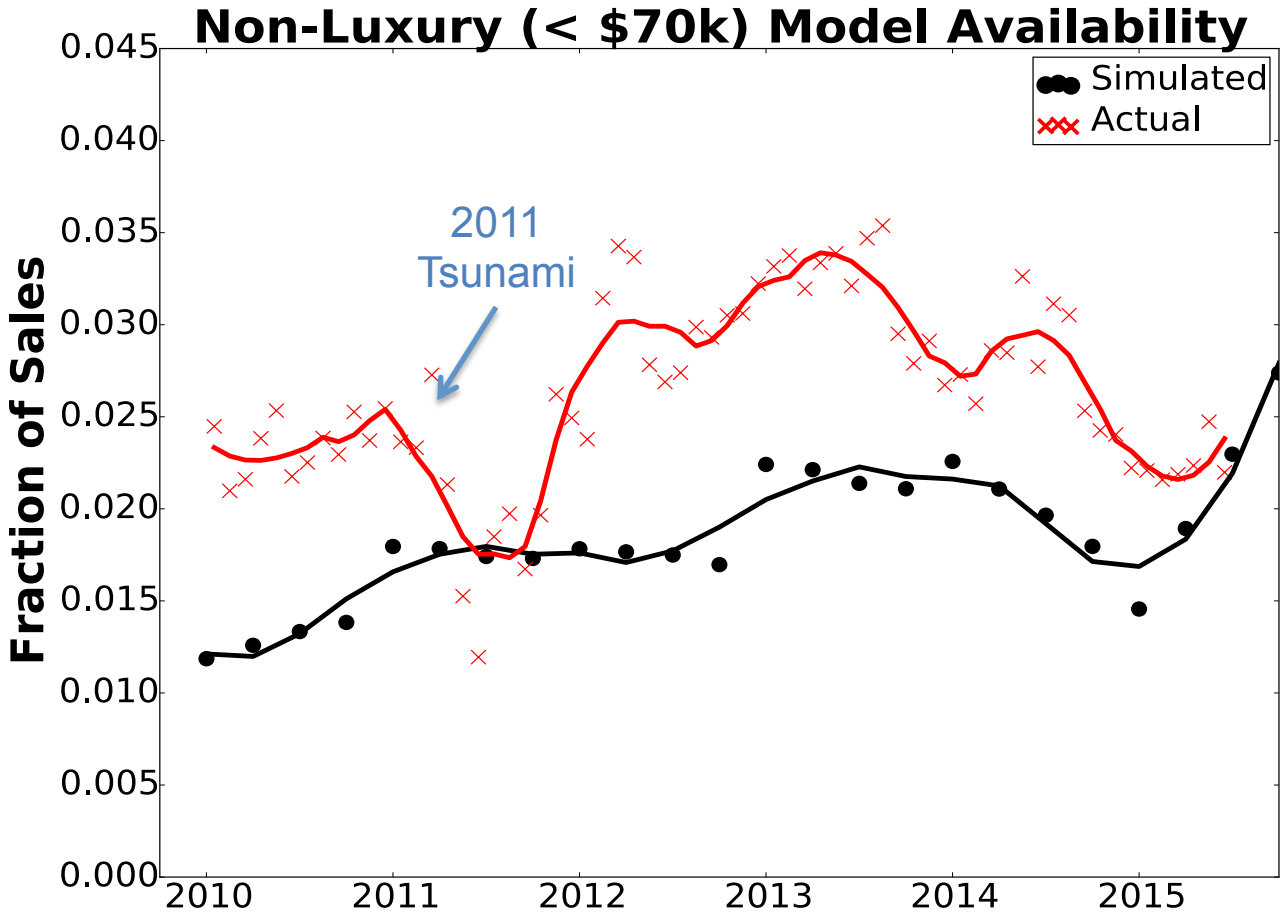




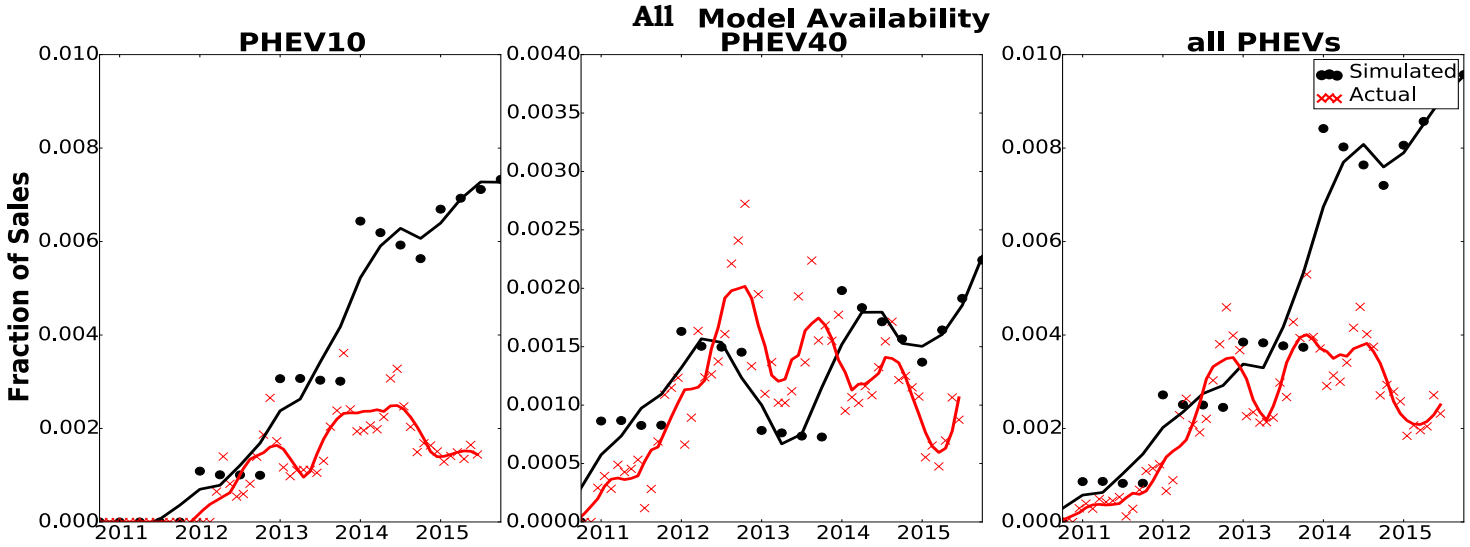
Simulation is capturing consumer responses to changes in commodity prices and other market factors. We CAN capture sensitivities.

Garbage in, garbage out: if input projections are off, so are the output projections.

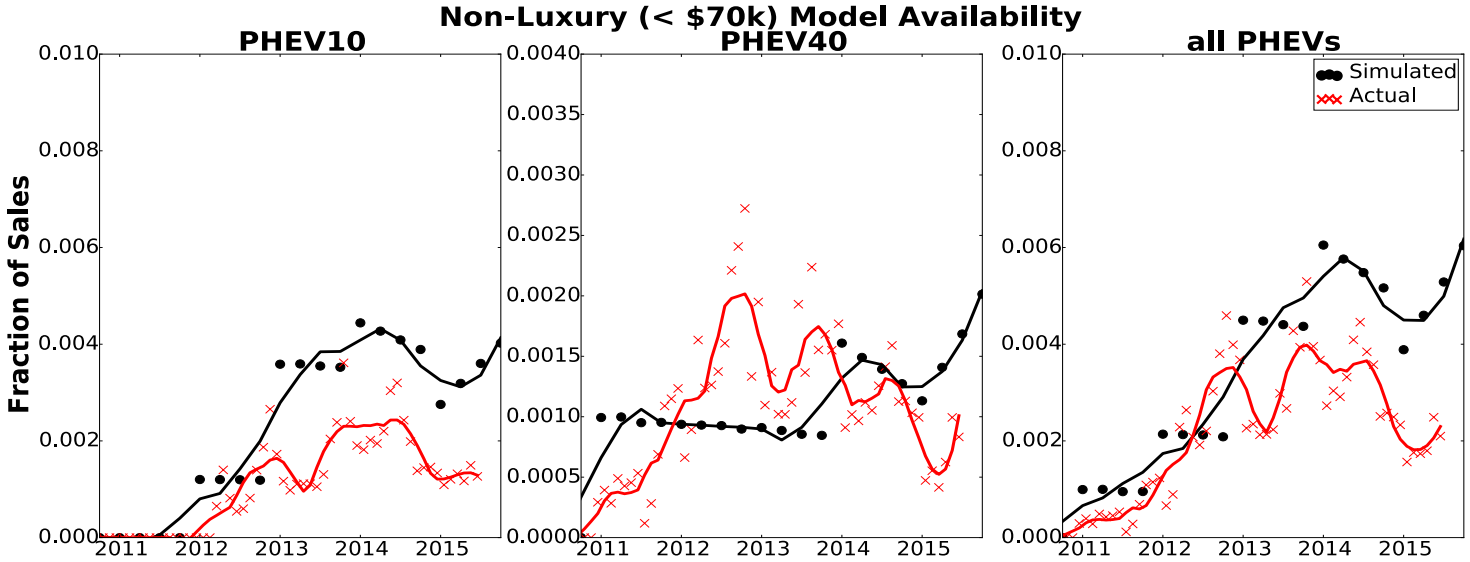
Hybrid Vehicles- simulation capturing long term trends and scales



PEVs – model availability is important, early adopter segment may be



Simulation matches less well if all models considered.



Simulation matches better if only non-luxury models considered.

Though there are obviously still some un-captured trends.

Conclusion

Purpose of the model?

- Understand composition of US LDV stock through 2050
- Sensitivities to commodity prices, technology advancements, policy …

How does the model work?

- Feedback between energy and vehicle stock
- Run thousands of times to create scenario library and probe sensitivities

How has the model evolved?

- Capability, technology additions – to support new projects
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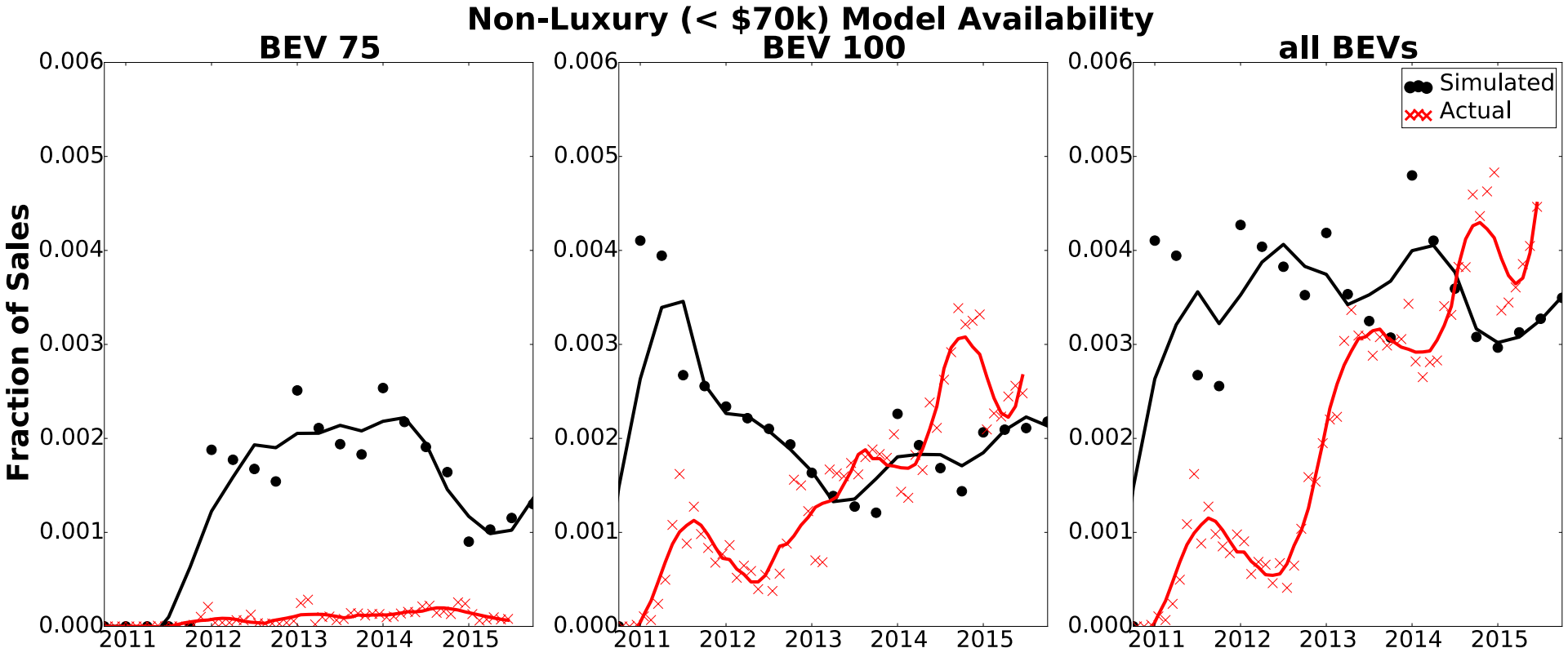
What have we learned looking back?

- Simulation captures trends in consumer behavior, scales of sales
- Vehicle model availability is important and complex to model
- Early adopter segmentation is likely important

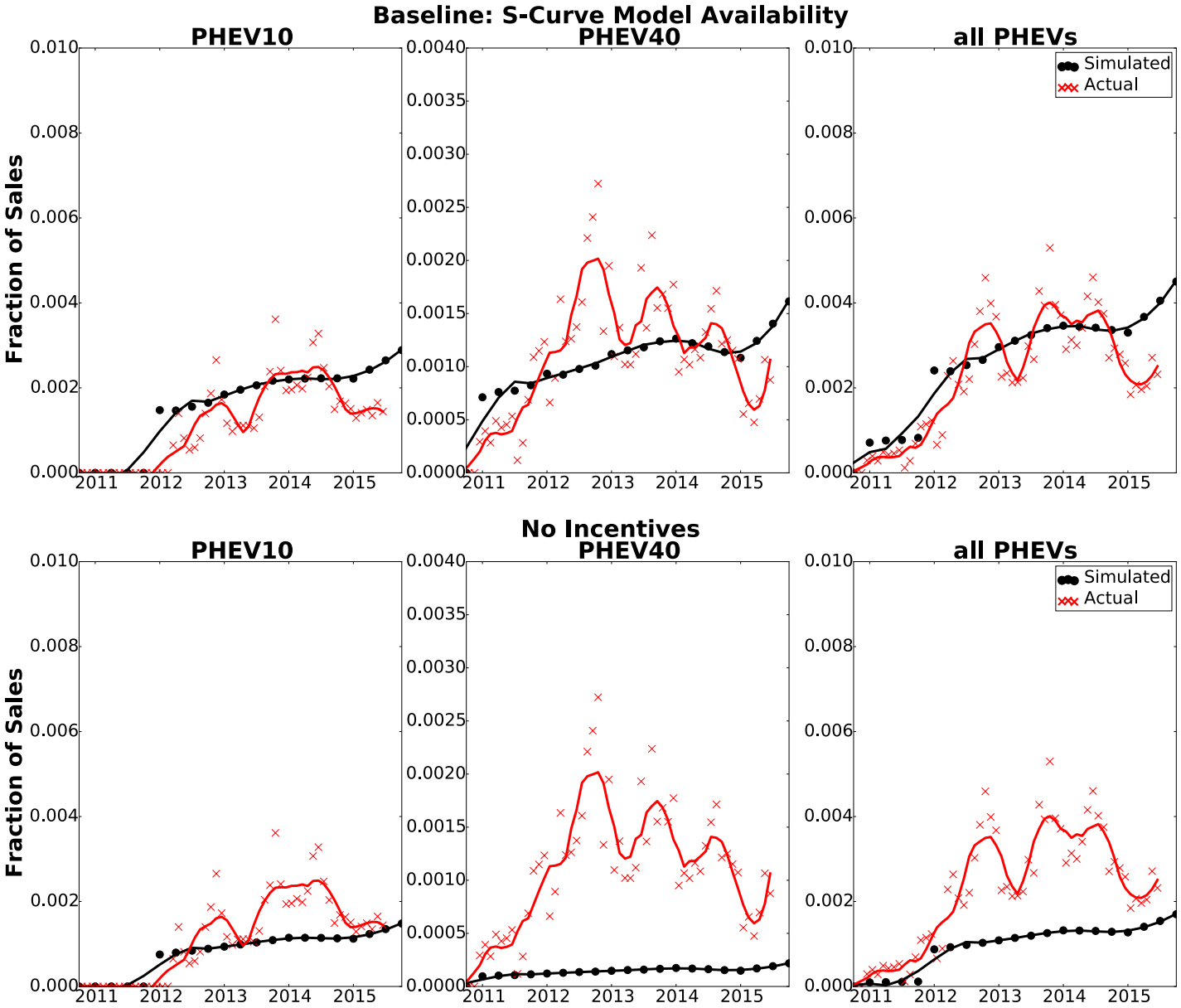
How has looking back pointed us forward?

- Have added confidence in the simulation dynamics
- Will incorporate early adopter segment, look carefully at model availability

BEVs– early adopter segment is important to simulate



Purchasing incentives are important to consumers.



PHEV makes, models, and approximate ranges and prices

Make & Model	eRange (miles)	MSRP ($1000)	Years
PHEV10s (25mi or less eRange)			
BMW i8	15	136	2014-2015
Ford C-MAX Energi	20	32	2013-2015
Ford Fusion Energi	20	36	2013-2015
Honda Accord	13	40	2014
McLaren P1	19	1150[a]	2014-2015
Porsche 918 Spyder	12	845	2015
Porsche Cayenne S	14	76	2015
Porsche Panamera S	16	99	2014-2015
Toyota Prius	11	31	2012-2015
PHEV40s (26mi or greater eRange)			
BMW i3 REX	72	46	2014-2015
Cadillac ELR	37	75	2014-2015
Chevrolet Volt	37[b]	37[b]	2011-2015
Fisker Karma	33	102	2012

Publications

Barter GE, Reichmuth D, Westbrook J, Malczynski LA, West TH, Manley DK, Guzman KD, & Edwards DM. (2012). Parametric analysis of technology and policy tradeoffs for conventional and electric light-duty vehicles. *Energy Policy*, 46(0), 473 – 488.

Barter GE, Reichmuth D, West TH & Manley DK. (2013) The future adoption and benefit of electric vehicles: a parametric assessment. *SAE Int. J. Alt. Power*, 6(1).

Peterson MB, Barter GE, West TH & Manley DK. (2014). A parametric study of light-duty natural gas vehicle competitiveness in the United States through 2050. *Applied Energy*, 125, 206–217.

Westbrook J, Barter GE, Manley DK & West TH. (2014). A parametric analysis of future ethanol use in the light-duty transportation sector: Can the US meet its Renewable Fuel Standard goals without an enforcement mechanism?. *Energy Policy*, 65, 419-431.

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Levinson RS, Manley DK & West TH. (2015). History v. Simulation: An analysis of the drivers of alternative energy vehicle sales, *Manuscript submitted for publication*.